

VIII.—REPORT UPON THE INVERTEBRATE ANIMALS OF VINEYARD SOUND AND THE ADJACENT WATERS, WITH AN ACCOUNT OF THE PHYSICAL CHARACTERS OF THE REGION.

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A.—HABITS AND DISTRIBUTION OF THE INVERTEBRATE ANIMALS.

I.—GENERAL REMARKS.

The investigation of the invertebrate life of these waters, undertaken at the request of the United States Commissioner of Fish and Fisheries, was actively carried forward during the entire summer of 1871, and the very extensive collections then made have been studied by Mr. S. I. Smith, Mr. O. Harger, and myself, as thoroughly as possible during the time that has been at our disposal. The work upon the collections is by no means complete, but is sufficiently advanced to serve the immediate purposes of the Fish Commission.

To Mr. Smith I am indebted for the identification of all the Crustacea referred to in this report and the accompanying lists, except the Isopods, which have been determined mostly by Mr. Harg r, to whom my thanks are also due for several excellent drawings of those animals. To Professor A. Hyatt I am indebted for the identification of some of the Bryozoa, and for most of the figures of that class. I am also under obligations to Dr. A. S. Packard, Dr. G. H. Horn, and Dr. H. A. Hagen, who have identified the insects inhabiting salt water.

According to the plans adopted these explorations had in view several distinct purposes, all more or less connected with the investigation of the fisheries. The special subjects attended to by this section of the Fish Commission party were chiefly the following :

1st. The exploration of the shores and shallow water for the purpose of making collections of all the marine animals and alg e living between tides, on every different kind of shore, including the numerous burrowing-worms and crustacea, and to ascertain as much as possible concerning their habits, relative abundance, stations, &c.

2d. The extension of similar observations by means of the dredge, trawl, tangles, and other instruments, into all depths down to the deepest waters which were accessible to us, and to make a systematic survey, as complete as possible, of all the smaller bays and harbors within

our reach, both to obtain complete collections of the animals and plants and to ascertain the precise character of the bottom, special attention being paid to the localities known to be the feeding-grounds of valuable fishes, and to those animals upon which they are known to feed.

3d. The depth of the water and its temperature, both at the surface and bottom, was to be observed and recorded in as many localities as possible, and especially where dredging was to be done, and lists of the animals and plants from special localities or depths were to be prepared, so as to show the influence of temperature and other physical features upon animal and vegetable life. Many valuable observations of this kind were made.

4th. The life of the surface waters was to be investigated by means of hand-nets and towing-nets, on every possible occasion, and at all hours. Towing-nets of different sizes, made of strong embroidery-canvas, and attached to stout brass rings, were used with excellent results, but very many interesting things were obtained by hand-nets skillfully used. The surface collections are of great interest in themselves, and of special importance practically, as they show the nature of the food of those fishes that feed at or near the surface.

5th. The collections obtained were to be preserved by the best methods: 1st, for the purpose of making a more thorough study of them than could usually be done at the time, and for the purpose of insuring accuracy in their identification and fullness in the special lists for the final reports; and 2d, in order to supply the Smithsonian Institution, Yale College museum, and a number of other public museums, both American and foreign, with sets of the specimens collected. For this last purpose large quantities of duplicates were collected and preserved, and will be distributed at an early day.

6th. Those species of animals which cannot be preserved in good condition for study were to be examined with care and minutely described while living. The colors and appearance of the soft parts of other species were to be described in the same way, and also the eggs and young of all kinds.

7th. It was regarded as of great importance to secure accurate drawings of the living animals, and especially of such as greatly change their form and appearance when preserved, such as worms, naked mollusks, ascidians, polyps, &c. Unfortunately the available funds were not sufficient to enable us to employ a special artist for this purpose during the summer, but this deficiency has been partially remedied by the figures subsequently drawn by Mr. J. H. Emerton, Mr. S. I. Smith, Mr. O. Harger, and the writer.

8th. In all these investigations the relations existing between the fishes and the lower animals which serve as food for them were to be constantly borne in mind, and all information bearing directly upon this subject that could be obtained was to be recorded. To this end large numbers of stomachs from fishes newly caught were examined, and

lists of the species found in them were made. Most of those thus ascertained to be their ordinary food were traced to their natural haunts from whence the fishes obtain them.

9th. The parasites of fishes, both external and internal, were to be collected and preserved for future study.

A large collection of such parasites was made, but the internal parasites, which are very numerous, have not yet been studied. The internal parasites were collected chiefly by Dr. Edward Palmer.

The map accompanying the present report serves to show the localities explored, and the extent of the labor in dredging and sounding. The operations during the first six weeks were under the charge of Mr. S. I. Smith, who remained until July 25. He was assisted by Dr. W. G. Farlow, who also investigated the algæ. Professor J. E. Todd, of Tabor, Iowa, then took charge of the work for three weeks, until I was able to join the party, on the 16th of August. During the remainder of the season, until September 20, the operations were under my immediate superintendence; but Professor A. Hyatt, of Boston; Dr. A. S. Packard, of Salem; Dr. Farlow, of Cambridge; and Professor D. C. Eaton, of New Haven, gave very important aid in carrying out our investigations, and our thanks are due to all of these gentlemen for their assistance. Several other naturalists were present, from time to time, and coöperated with our party in various ways.

The dredging operations in the shallow waters of Vineyard Sound and Buzzard's Bay were carried on at first by means of a sail-boat, but during the greater part of the time by means of a steam-launch. The dredgings outside of these waters, and off Martha's Vineyard, were all done by means of a United States revenue-cutter, the steamer *Moccasin*, under command of Captain J. G. Baker. Our thanks are due to the officers of the *Moccasin*, who were very courteous, and gave us all the facilities within their power for carrying out our investigations successfully. Without this important assistance we should have remained in complete ignorance of the temperature and peculiar fauna of the deeper waters off this shore, for the localities were too distant to be reached by means of the steam-launch or sail-boats.

The examination of the bottom was done by means of dredges of various sizes, constructed much like those in general use for this purpose; by "rake-dredges" of novel construction, consisting of a heavy A-shaped iron frame, to the arms of which bars of iron armed with long, thin, and sharp teeth, arranged like those of a rake, are bolted, back to back; a rectangular frame of round iron, supporting a deep and fine dredge-net, follows just behind the rake to receive and retain the animals raked from the soft mud or sand by the rake; a trawl-net, with a beam about fourteen feet long, made of stout, iron gas-pipe, and having a net, fine toward the end, about forty feet deep, and provided with numerous pockets; "tangles," consisting of an A-shaped iron frame, to which frayed-out hemp-ropes are attached. The best form

has several small chains of galvanized iron attached to the frame by one end, so as to drag over the bottom, and the pieces of frayed-out rope are attached along the sides of the chains.

The ordinary dredges can be used on all kinds of bottom, except where there are rough rocks and ledges, but they generally merely scrape the surface or sink into the bottom but slightly. The rake-dredges are used only on bottoms of soft mud or sand, and are intended to catch burrowing animals of all kinds, which are always numerous on such bottoms. The trawl is adapted for the capture of bottom-fishes, as well as for crabs, lobsters, large shells, and all other animals of considerable size, which creep over or rest upon the bottom. It cannot be used where the bottom is rocky or rough, and does not usually capture many animals of small size, or those that burrow. It is, however, a very important instrument when used in connection with the ordinary dredge, for it will capture those species which are too active to be caught by the dredge, and much greater quantities of the larger species than can be obtained by the dredge alone. The "tangles" are particularly useful on rough, rocky, or ledgy bottoms, where the dredge and trawl cannot be used, but they cannot be depended upon for obtaining all the small species, especially of shells and worms. They capture mainly those kinds of animals which have rough or spiny surfaces, such as star-fishes, sea-urchins, corals, bryozoa, rough crabs, &c., and those kinds which are disposed to cling to foreign objects, such as many of the small crustacea, which are often taken in countless numbers by this means. Star-fishes and sea-urchins are especially adapted to be caught by this instrument, and are often brought up in great quantities. The tangles can be used on all kinds of bottoms, wherever there are any of those kinds of animals which they are adapted to capture.

The localities where dredgings were made by these various instruments were located on Coast Survey charts as accurately as possible, and were sufficiently numerous to give a pretty satisfactory knowledge of the nature of the bottom and its inhabitants throughout the region explored. The total number of casts of the dredges made during the three months devoted to this work was about 400. A large part of these, including all the more important ones, have been located on the map accompanying this report. The more important points where the temperature of the water was observed have also been indicated on the map and the temperatures given, the figures *above* two parallel lines indicating the surface temperature, those *below* such lines indicating the bottom temperature—thus: $\frac{62}{57}$.

In prosecuting our explorations we soon found that there are, in the waters of this region, three quite distinct assemblages of animal life, which are dependent upon and limited by definite physical conditions of the waters which they inhabit. The first of these includes all those kinds which inhabit the bottom and shores of Vineyard Sound, Buzzard's Bay, and the other similar bodies of shallow water along this coast from

Cape Cod westward and southward. These shallow waters consist of nearly pure sea-water, which has a relatively high temperature, especially in summer, for it is warmed up both by the direct heat of the sun, acting on the shallow waters spread over broad surfaces of sand, and by water coming directly from the Gulf Stream, and bringing not only its heat, but also its peculiar pelagic animals. The temperature at the surface in August was 66° to 72° Fahrenheit. Owing to this influence of the Gulf Stream these waters never become very cold in winter, for some of the small, shallow harbors never freeze over. The greater part of the animals inhabiting these bays and sounds are southern forms.

The second assemblage is a very peculiar one, which inhabits the estuaries, ponds, lagoons, harbors, and other similar places, where the water is shallow and more or less brackish, and very warm in summer, but cold in the winter. The third group inhabits the shores of the outer islands and headlands and the bottoms in moderately deep water, outside of the bays and sounds. These outer waters are comparatively cold, even in summer, and are no doubt derived from an offshoot of the arctic current, which drifts southward along our shores in deep water and always has a tendency to crowd against and up its submarine slopes, in which it is also aided in many cases by the tides. In August, the temperature of the surface was 62° to 65° , of the bottom 57° to 62° Fahrenheit. The animals inhabiting these cold waters are mostly northern in character and much like those of the coast of Maine and Bay of Fundy. The surface waters in the bays and sounds, although usually somewhat warmer in summer than those outside, differ less in temperature than the bottom waters. Consequently we find less difference in the surface animals. We have therefore found it most convenient to group all the surface animals together, as a special division of those inhabiting the bays and sounds. In each of the groups or assemblages we find that certain kinds are restricted to particular localities, depending upon the character of the bottom or shore. Thus there will be species, or even large groups of species, which inhabit only rocky shores; others which inhabit only sandy shores; others which dwell in the muddy places; and still others that prefer the clean gravelly bottoms where the water is several fathoms deep, &c.

I have found it desirable, therefore, in describing the character of the marine life of this region, to group the animals according to the localities which they inhabit, adopting the three primary divisions given above, but, for greater convenience of reference, placing all the parasitic species together in one group. The subdivisions of these groups will be given under each, in the succeeding pages.

The primary groups will stand as follows:

1. The fauna of the bays and sounds.
2. The fauna of the estuaries and other brackish waters.
3. The fauna of the cold waters of the ocean shores and outer banks and channels.

In describing the animals belonging in these different divisions and subdivisions it has not been found desirable to mention, in this part of the report, all the species found in each, but only those that appear to be the most abundant and important, and especially those that are known to serve as the food of fishes. But in the general systematic list, which accompanies this report, all the species of the region, so far as determined, will be enumerated.

II.—THE FAUNA OF THE BAYS AND SOUNDS.

In Buzzard's Bay, Vineyard Sound, Nantucket Sound, and Muskeget Channel, (see map,) the water is shallow, being generally less than 8 fathoms deep, and rarely exceeding 14 fathoms, even in the deepest spots. It will be seen by reference to the map, on which soundings have been given and contour lines drawn, representing the zones having depths below 3, 10, 14, and 20 fathoms, respectively, that the greater part of Buzzard's Bay is less than 10 fathoms deep, and that the 3-fathom curve is nearly parallel with the shore lines, and the same is true of the 6-fathom line, which has not been drawn. The 10-fathom curve is very irregular and only extends a short distance within the mouth of the bay; but an irregular area, in which the water exceeds 10 fathoms in depth, the central part over a limited area being about 15 fathoms, is situated to the west of Penikese, Nashawena, and Cuttyhunk Islands; this is inclosed on all sides by shallower water. The 14-fathom curve is situated from four to eight miles farther off and does not enter the bay at all, showing only a very slight curvature in that direction; yet it extends far up Narragansett Bay, and to a considerable distance within the mouth of Vineyard Sound, but, like the 10-fathom line, does not enter Muskeget Channel or Nantucket Sound at any point, and shows scarcely any curvature toward those waters, which are very shallow throughout their whole extent, and much obstructed by banks and broad shoals of moving sands. The 20-fathom line at nearly all points is situated far off shore, and does not conform at all to the outline of the coast. There is, however, an area of water exceeding this depth off Newport, in the mouth of Narragansett Bay.

Vineyard Sound is deeper and much more varied in its depth and in the character of its bottom than Buzzard's Bay or Nantucket Sound, and therefore its fauna is richer in species and the facilities for collecting are much greater. In Vineyard Sound the 3-fathom curve follows the outlines of the shore very closely, and the same is true of the 6-fathom curve, which has not been represented on the map. The 10-fathom line when it enters the mouth of the sound incloses the greater part of its width and is approximately parallel with its shores, but after it passes the narrowest part of the sound, between the northern end of Martha's Vineyard and Wood's Hole, it rapidly narrows and is finally interrupted by shallows and sand-bars after passing Holmes's Hole, but there are beyond this several isolated areas of water exceeding this depth and having their long

axes nearly parallel with the central axis of the channel, or rather parallel with the direction of the tidal currents. One of these areas, south of Osterville, Massachusetts, is 15 fathoms deep, but of no great size. These deeper depressions are surrounded by banks and ridges of sand, some of which rise nearly to the surface and form dangerous shoals; the shoals, like the deep channels, have their longer axes parallel with the prevailing tidal currents, but as they are mostly composed of loose moving sands, they are liable to be altered in form and position by severe storms.

These moving sands are generally very barren of life, and form true submarine deserts. Included within and nearly inclosed by the 10-fathom line, there is, between Martha's Vineyard and Naushon Island, a large area of shallower water, which is connected with the shallow water of the shore at the northern end of Martha's Vineyard, off the "West Chop," near Holmes's Hole. In some places this shallow rises nearly to the surface and forms the "middle ground," and other shoals parallel with the current that sets through the channels on either side, and consequently nearly parallel with the shore of Martha's Vineyard. It is evident that this rather extensive bank is due to the action of the tidal current which sweeps around West Chop toward the mouth of the sound, following the direction of the deeper channels, the projecting point at West Chop furnishing a lee in which the movement of the water is retarded and the sediment deposited; but this action is modified by the tidal current which enters the mouth of the sound and flows in the opposite direction, for although this current is somewhat less rapid, its duration is longer, especially that branch of it which flows between the Middle Ground Shoal and Martha's Vineyard, for this flows eastward seven hours and twenty-six minutes, while the opposite current flows westward for only four hours and thirty-four minutes; the effect of the current flowing eastward would, therefore, be to keep this channel from filling up by the sediments carried along by the westward currents. The same effect would be produced in the main channel, outside of this shoal, although the difference in the duration of the flow in the two directions is there less, the eastward flow lasting six hours and fifteen minutes, while the westward tide lasts five hours and forty-five minutes.

Similar causes determine, without doubt, the position of all the other shoals and banks of sand in this region, as well as the existence of the isolated deep areas between them, but in many cases the direction of the wind-waves produced by the more violent storms must be taken into account. The 14-fathom line extends into the mouth of the sound, as far as a point opposite Nashawena Island; and beyond this there are several isolated areas which are of this depth; the most extensive of these is opposite the southern half of Naushon Island and in a line with the main channel at the mouth of the sound. Since the tides are greater in Buzzard's Bay than in Vineyard Sound, and neither the times of low

water and high water, nor the relative duration of the ebb and flow are coincident, very powerful currents set through the passages, between the Elizabeth Islands, connecting these two bodies of water. This is most noticeable in the case of Wood's Hole, because there the channel is narrow and shallow, and much obstructed by rocks. These channels are, therefore, excellent collecting grounds for obtaining such animals as prefer rocky bottoms and rapidly flowing waters.

The shores of Vineyard Sound and Buzzard's Bay are quite diversified and present nearly all kind of stations usually found in corresponding latitudes elsewhere, except that ledges of solid rock are of rare occurrence, but there are numerous prominent points where the shore consists of large rocks or boulders, which have been left by the denudation of deposits of glacial drift, forming the cliffs along the shores. Sandy beaches are frequent, and gravelly and stony ones occasionally occur. Muddy shores are less common and usually of no great extent.

In Buzzard's Bay the bottom is generally muddy, except in very shallow water about some of the islands, where patches of rocky bottom occur, and opposite some of the sandy beaches where it is sandy over considerable areas. Tracts of harder bottom, of mud or sand, overgrown with algæ, occasionally occur. In Vineyard Sound the bottom is more varied. It is sandy over large districts, especially where the shoals occur, and in such places there are but few living animals, though the sand is often filled with dead and broken shells, but in other localities the sand is more compact and is inhabited by a peculiar set of animals. Other extensive areas have a bottom of gravel and small stones and broken shells; on such bottoms animal life is abundant, and the entire bottom seems to be covered in some places by several kinds of compound ascidians, which form large masses of various shapes, often as large as a man's head. In still other places, chiefly off rocky points and in the channels between the islands, rocky bottoms occur, but they are usually of small extent. Muddy bottoms are only occasionally met with. They occur in most of the deep areas which are isolated, and sometimes in the deep channels, but are more common in sheltered harbors and coves.

In Nantucket Sound and Muskeget Channel the bottom is almost everywhere composed of sand, and the same is true of an extensive area to the east and northeast of Nantucket Island, where shoals of moving sand are numerous and often of large size, but in the partially sheltered area on the north side of Nantucket, there is more or less mud mixed with the sand.

For greater convenience the following subdivisions have been adopted in describing the animals of the bays and sounds:

1. Rocky shores, between high-water and low-water marks.
2. Sandy and gravelly shores.
3. Muddy shores and flats.
4. Piles of wharves, buoys, &c.

5. Rocky bottoms below low-water mark.
6. Stony, gravelly, and shelly bottoms.
7. Sandy bottoms.
8. Muddy bottoms.
9. Free-swimming and surface animals.
10. Parasitic animals.

It must, however, be constantly borne in mind that very few kinds of animals are strictly confined to any one of these subdivisions, and that the majority are found in two, three, or more of them, and often in equal abundance in several, though each species generally *prefers* one particular kind of locality. In other cases the habits vary at different seasons of the year, or at different hours of the day and night, and such species may be found in different situations according to the times when they are sought. The more common and characteristic species are, however, pretty constant in their habits and may be easily found in their respective stations at almost any time.

Since those animals that inhabit the shores, between tides, are most frequently seen and can be most easily obtained and studied by those who are not professional naturalists, I have entered into more details concerning their habits and appearances than in the case of those obtained only by dredging. Such species as have not been previously named and described in other works will be more fully described in the systematic list, to follow this report, and references will there be given to descriptions of the others.

II.—1. ANIMALS INHABITING THE ROCKY SHORES OF THE BAYS AND SOUNDS.

The principal localities where these animals were studied and collected are at Nobska Point, just east of Wood's Hole; Parker's Point, between Great Harbor and Little Harbor, near Wood's Hole; the neck of land north of Wood's Hole Channel; several localities on Naushon and the adjacent islands; and numerous localities on the shores of Long Island Sound, as at Savin Rock and Light-House Point, near New Haven; Stony Creek; Thimble Islands, &c.

In all these places the rocks, in a zone extending from near low-water mark of ordinary tides to near half tide, are generally covered with an abundance of "rock-weeds," (*Fucus nodosus* and *F. vesiculosus*,) which hang in great olive-brown clusters from the sides of the rocks or lie flat upon their surfaces when left by the tide, but are floated up by means of their abundant air-vessels when the tide rises. Mingled with these are several other algæ, among which the green "sea-cabbage" (*Ulva latissima*) is one of the most abundant. Below this zone of *Fucus* there is a narrow zone which is only exposed during spring-tides; in this the *Ulva* and many other more delicate green and red algæ flourish. Above the *Fucus*-zone there is another zone of considerable width which is covered for a short time by every tide; and still higher

up another zone which is ordinarily only washed by the waves and spray, but is in part occasionally covered by unusually high tides. As the tides do not rise very high in this region these zones are all much narrower and less distinctly marked than on the coast further north, and especially on the coast of Maine and in the Bay of Fundy, but yet they can always be easily recognized and distinguished by their peculiar forms of animal and vegetable life. Pools of sea-water left by the tide frequently occur in each of these zones, among the rocks, and afford excellent opportunities for studying and collecting the animals.

The animals of rocky shores are to be sought for in a variety of ways. A few occur quite exposed, clinging to the rocks or weeds, in defiance of the surf. These are chiefly univalve shells, barnacles, and such animals as grow like plants, firmly attached to solid objects, among these are the bryozoa, hydroids, and sponges. A much larger number seek shelter under the rocks, or on their lower sides, or in crevices and cavities between them; these must be sought by turning over the rocks and exploring the crevices concealed by the *Fucus*, &c. Many other species conceal themselves still more effectually by burrowing in the mud, gravel, and sand beneath and between the rocks; these are often uncovered in turning over the rocks, but must also be sought for by digging with a spade, stout trowel, or some other tool, in the dirt exposed when the rocks are removed. The number of curious species of annelids, holothurians, bivalve-shells, actiniæ, &c., which can be unearthed in this way is always very surprising to the inexperienced in this kind of collecting. Still other kinds can be found by carefully examining the pools and discovering the smaller animals by their motions, or by the shadows that they cast when the sun shines, or by noticing their burrows, or, if time will not admit of a more careful examination, by sweeping a fine hand-net through the weeds along the edges. Many small crustacea, shells, etc., may also be found clinging to the corallines and other algæ growing in such pools, or even among the algæ lying upon the rocks, and especially among masses of detached algæ, thrown up by the waves.

In the uppermost zone the animals are of comparatively few kinds, but these usually occur in great abundance. The most conspicuous is, perhaps, the common "rock-barnacle" or "acorn-shell," *Balanus balanoides*, which adheres firmly to the rocks by its base and can resist the most violent surf, even on the outer ocean shores. When left by the tide these dull white conical shells are not calculated to attract much attention, except on account of their vast numbers, for they sometimes completely whiten the rocks for long distances along the zone in which they flourish best, and even so crowd against each other that they cannot assume their normal form, but become greatly elongated. But when the tide comes in, each one lifts up the double-door which closes the aperture at the summit of the shell and puts out an organ, bearing a cluster of gracefully curved and fringed arms, which

it quickly sweeps forward with a grasping motion and then quickly withdraws, as if in search of food, and this motion will be repeated with great regularity for a long time, unless the creature be disturbed, when it instantly withdraws its net and closes its doors. No one who will take the trouble to examine this little animal, when in active operation in one of the tide-pools, can fail to admire its perfect adaptation to its mode of life and the gracefulness of its motions. The movement referred to serves not only to obtain food, which, in the form of microscopic animals, is always abundant in the water, but also to supply fresh currents of water for respiration. This creature is also well worthy of mention here because it serves as food for the tautog, and probably for other fishes that can obtain it at high water.

Two species of small univalve shells (*Littorina*) are always to be found in abundance clinging to the surface of the rocks, or among the sea-weeds, or creeping about in the tide-pools. These are often found quite up to high-water mark, but the full-grown ones are more common lower down among the "rock-weeds." One of these (Plate XXIV, fig. 138) is subglobular in form, the spire being depressed and the aperture wide. This is the *Littorina palliata*. It varies much in color; the most common color is dark olive-brown, not unlike that of the *Fucus*, but orange-colored and pale yellow specimens are not uncommon, while others are mottled or banded with yellow or orange and brown. The second species is more elongated and has a more elevated and somewhat pointed spire. This is *Littorina rudis*, and it has many varieties of form, color, and sculpture; one of its varieties is represented on Plate XXIV, fig. 137. Some specimens are smooth, others are covered with revolving lines or furrows; in color it is most frequently dull gray, olive-green, or brown, but it is often prettily banded, checked, or mottled with yellow or orange, or even black, and sometimes with whitish. This species is viviparous. These shells are both vegetarians and feed upon the algæ among which they live. Another allied shell, the *Lacuna vineta*, (Plate XXIV, fig. 139,) is found clinging to the sea-weeds at low-water mark and sometimes in the tide-pools. This is usually pale reddish or purplish brown, or horn-colored, and most commonly is encircled by two or more darker, chestnut-colored bands. This also feeds upon the algæ. Associated with the last, two or three other kinds of small shells are generally found. One of the most abundant of these is the *Bittium nigrum*, (Plate XXIV, fig. 154,) which is, as its name implies, generally black, especially when young, but large specimens are often only dark brown or even yellowish brown below; it occurs in great abundance, clinging to the sea-weeds and eel-grass at and below low-water mark, and is also to be found in the tide-pools and on the under sides of rocks. Associated with the last, and resembling it in form and color as well as in habits, another much less common species occurs, which is remarkable for having its whorls reversed, or coiled to the left, in the direction opposite to that of most other shells. This is the *Triforis nigrocinctus*, (Plate

XXIV, fig. 152.) This species is more at home at the depth of a few fathoms, among algæ. Another still smaller and lighter colored species, which often occurs abundantly in similar situations, both on algæ and under stones, is the *Rissoa aculeus*, (Plate XXIV, fig. 141,) but this generally seeks more sheltered situations. All these shells feed upon the algæ. With them there can usually be found large numbers of several carnivorous species. The most abundant one is a small but pretty shell, having a smooth surface and quite variable in color, though usually reddish or purplish brown, and irregularly mottled or banded with yellowish or whitish, the light-colored spots often taking the form of crescents, and varying much in size and number. This is the *Astyris lunata*, (Plate XXI, fig. 110.) It lives among the algæ, and also among hydroids, and may be found in almost all kinds of localities, both above and below low-water mark. It is usually abundant on the under sides of rocks among hydroids, &c., and can nearly always be found in the tide-pools. Another allied species of larger size, and much less common, the *Anachis avara*, (Plate XXI, fig. 109,) often occurs with it. Clinging to the rocks, or sheltered in the crevices and on their under surfaces, a much larger, dull-white or grayish, roughly-sculptured shell can usually be found in abundance. This is the *Urosalpinx cinerea*, (Plate XXI, fig. 116,) which the oystermen call "the drill," a name very suggestive of its habits, for it gets its living, like many other similar univalve shells, by drilling a round hole, by means of the sharp, flinty teeth that cover its tongue, through the shells of oysters and other bivalves and then sucking out the contents at its leisure. It is usually very abundant on the oyster-beds, and often proves very destructive. Another shell of about the same size, somewhat resembling the last, and having similar habits, is often found associated with it on the more exposed rocky points, as at Nobska Point, the Wepecket Islands, &c. This is, however, a very northern and arctic shell, which extends also around the northern coasts of Europe, and is called *Purpura lapillus*, (Plate XXI, figs. 118 and 119;) it is here near its southernmost limits, for it is not found in Long Island Sound or farther south; while the former is a southern shell, abundant on the whole southern coast as far as the Gulf of Mexico, and rare north of Cape Cod, except in a few special localities of sheltered and warm waters. The *Purpura* is seldom found living much below low-water mark, and prefers the exposed rocky headlands on the ocean shores, where it flourishes in defiance of the breakers. It lays its eggs in smooth, vase-shaped capsules, attached to the sides or under surfaces of stones by a short stalk, and usually arranged in groups, (Plate XXI, fig. 120.) The eggs of "the drill" are laid in similar places, but the capsules have very short stalks, or are almost sessile, and are compressed, with an ovate outline, and angular ridges pass down their sides. The "limpet," another northern and European shell, having a low conical form, is occasionally found clinging to the rocks at low-water in this region, but is far more common north of

Cape Cod. This shell is the *Acmæa testudinalis*, (Plate XXIV, figs. 159, 159a;) it is extremely variable in color, but is most commonly radiated, checked, or tessellated with brown, pale greenish, and white. It grows much larger on the coast of Maine than here. A peculiar narrow form of this shell, (var. *alveus*,) represented by fig. 159b, lives on the leaves of eel-grass. Beneath the rocks, and generally attached to their under sides, among hydroids, bryozoa, &c., several species of small, slender, pointed, and generally whitish shells occur, which belong to the genus *Odostomia*. The most common of these are *O. trifida*, (Plate XXIV, fig. 145,) *O. bisuturalis*, (Plate XXIV, fig. 146,) and *O. fusca*, (Plate XXIV, fig. 144,) but other similar species are often to be found. These all have the singular habit of spinning a thread of mucus by means of which they can suspend themselves from any surface. In confinement they will often creep along the surface of the water, using the bottom of the foot as a float, in a manner similar to that of many fresh-water shells. On the under sides of rocks are occasionally found some very beautiful and interesting naked mollusks; but this group of animals is far less abundant in this region than farther north. The largest and finest species observed here is the *Doris bifida*, (Plate XXV, fig. 176,) which grows to be about an inch long. Its body is deep purple, specked with white and bright yellow, and the beautiful wreath of gills is covered with bright golden specks; the ends of the tentacles are also bright yellow. Its eggs are contained in convoluted gelatinous ribbons, which are attached to the under sides of rocks or in crevices. Another rare and curious species, the *Doridella obscura*, (Plate xxv, fig. 173,) is occasionally found on the under side of stones. This is a small, oval, flattened species, of a dark brown or blackish color, with small, white retractile tentacles on the back, but the gills are very small and situated underneath, near the posterior end of the body, in the groove between the mantle and foot. The eggs are inclosed in a delicate gelatinous string, which is coiled up something like a watch-spring, and attached to the under side of stones.

Of bivalve shells several species are common on rocky shores, especially in the crevices and under the rocks. Three kinds of muscles are usually met with. The species which lives at high-water mark, clustering about the small upper pools and in the crevices, and having its shell ribbed with radiating ridges and furrows, is the *Modiola plicatula*, (Plate XXXI, fig. 238.) This species is far more abundant, however, along the borders of estuaries and on salt marshes and muddy shores, always preferring the upper zone, where it is covered for a very short time by the tide. The most common species among the rocks, toward low-water mark, and in the larger pools, is the *Mytilus edulis*, (Plate XXXI, fig. 234,) which is the "common muscle" all along our coast from North Carolina to the Arctic Ocean. It is perfectly identical with the common muscle of Europe, which there forms a very important article of food, and in many places, as on the coast of France, is exten-

sively cultivated for the market. On our coast it is seldom used as food, although quite as good as on the European shores; but it is collected on some parts of our coast in vast quantities to be used for fertilizing the soil. It is most abundant in the shallow waters of bays and estuaries, where the water is a little brackish, but flourishes well in almost all kinds of situations where there is some mud, together with solid objects to which it can attach itself. Along the coasts of Long Island and New Jersey it is taken in almost incredible quantities from the shallow sheltered bays and lagoons that skirt those shores. It grows very rapidly and under favorable conditions becomes full grown in one season. Like all other kinds of true muscles, it has the power of spinning strong threads by means of the groove in its long, slender foot, and, by extending the foot, glues them firmly by one end to rocks, shells, or any other solid substances, while the other end is firmly attached to its body. When they attach their threads to their neighbors they form large clusters. Thus a very firm and secure anchorage is effected, and they are generally able to ride out the most violent storms, though, by the giving way of the rocks or shells to which they are attached, many are always stranded on the beaches after severe storms. They are not confined to the shallow waters, for very large specimens were dredged by me, several years ago, in 40 to 50 fathoms in the deep channels between Eastport, Maine, and Deer Island, where the tide runs with great force; and it has since been dredged by our parties in still deeper water in the same region, showing that it can live and prosper equally well under the most diverse conditions. The specimens from sheltered localities and sandy bottoms are, however, much more delicate in texture and more brilliant in color than those from more exposed situations. Some of the thinner and more delicate specimens, from quiet and pure waters, are translucent and very beautifully colored with brown, olive, green, yellow, and indigo blue, alternating in radiating bands of different widths; while others are nearly uniform pale yellow, or translucent horn-color. Those from the exposed shores are generally thicker, opaque, and plain dull brown, or bluish black, and not unfrequently they are very much distorted. This species breeds early in the spring. I have found immense numbers of the young, about as large as the head of a pin, which had just attached themselves to algæ, hydroids, &c., on the 12th of April. These shells are not destined to remain forever fixed, however, for they not only swim free when first hatched, but even in after life they can, at will, let go their anchor-threads, or "byssus," and creep about by means of their slender "foot," until they find another anchorage that suits them better, and they can even climb up the perpendicular sides of rocks or piles by means of the threads of the "byssus," which they then stretch out and attach, one after another, in the direction they wish to climb, each one being fastened a little higher up than the last. Thus, little by little, the heavy shell is drawn up, much in the manner employed by some spiders when moving or suspending an

unusually large victim. This common muscle is not only useful to man directly as food, and as a fertilizer, but it serves as an important article of food for many fishes, both in its young stages and when full grown. The tautog makes many a hearty meal on the full-grown shells, as do several other kinds of fishes, while the "scup" and others devour the young. The common star-fishes feed largely upon muscles, as well as oysters, and they also have many other enemies. A small parasitic crab, *Pinnotheres maculatus*, lives in their shells, between their gills, in the same manner as the common *Pinnotheres ostreum* lives in the oyster. Another larger muscle, sometimes called the "horse-muscle," which is the *Modiola modiolus*, (Plate XXXI, fig. 237,) lives at extreme low-water mark in the crevices between the rocks, and usually nearly buried in the gravel and firmly anchored in its place. Sometimes it occurs in the larger pools, well down toward low-water mark. It is, like the last, a northern species, and extends to the Arctic Ocean and Northern Europe. It is much more abundant on the northern coasts than here, and, although it is almost entirely confined to rocky shores and bottoms, it extends to considerable depths, for we dredged it abundantly in the Bay of Fundy, at various depths, down to 70 fathoms. Like the preceding, it is devoured by the tautog and other fishes. Its thick shell, covered with a glossy, chestnut epidermis, and rudely hairy toward the large end, are points by which it can easily be recognized, and its shape is also peculiar. The common "long clam," *Mya arenaria*, (Plate XXVI, fig. 179) is very often met with buried in the sand and gravel beneath stones and rocks, but it is far more abundant on sandy and muddy shores, and especially in estuaries, and will, therefore, be mentioned with more details in another place.

Another shell, somewhat resembling the "long clam," but never growing so large, and more cylindrical in form though usually much distorted, is occasionally met with under the rocks or in crevices. This is the *Saxicava arctica*, (Plate XXVII, fig. 192.) It is much more abundant farther north, and has a very extensive range, being found on most coasts, at least in the northern hemisphere. On those coasts where limestone exists it has the habit of burrowing into the limestone, after the manner of *Lithodomus* and many other shells. The only localities on our coast where I have observed this habit are at Anticosti Island, in the Gulf of Saint Lawrence, where the soft limestones are abundantly perforated in this way. On the New England coast limestones rarely occur, and they have to be content with such cracks and crannies as they can find ready made; consequently their shells, in growing to fit their places, become very much distorted. This species can also form a byssus, when needed, to hold its shell in position. The siphon-tube is long and much resembles that of *Mya*, (see fig. 179,) but is divided at the end for a short distance, and generally has a reddish color. The "bloody clams," *Scapharca transversa*, (Plate XXX, fig. 228,) and *Argina pexata*, (Plate XXX, fig. 227,) are occasionally

met with at low water, under or among rocks, and generally attached by a byssus, but their proper home is in the shallow waters off shore, especially on muddy, shelly, and gravelly bottoms. The fishermen call them "bloody clams," because the gills are red, and when opened they discharge a red fluid like blood. The little shell called *Kellia planulata* (Plate XXX, fig. 226) is also sometimes found under stones at low water. Attached to the sides and surfaces of rocks and ledges along many parts of this coast, young oysters, *Ostrea Virginiana*, often occur in vast numbers, sometimes completely covering and concealing large surfaces of rocks. But these generally live only through one season and are killed by the cold of winter, so that they seldom become more than an inch or an inch and a half in diameter. They come from the spawn of the oysters in the beds along our shores, which, during the breeding season, completely fill the waters with their free-swimming young. They are generally regarded as the young of "native" oysters, but I am unable to find any specific differences between the northern and southern oysters, such differences as do exist being due merely to the circumstances under which they grow, such as the character of the water, abundance or scarcity of food, kind of objects to which they are attached, age, crowded condition, &c. All the forms occur both among the northern and southern ones, for they vary from broad and round to very long and narrow; from very thick to very thin; and in the character of the surface, some being regularly ribbed and scalloped, others nearly smooth, and others very rough and irregular, or scaly, &c. When young and grown under favorable conditions, with plenty of room, the form is generally round at first, then quite regularly oval, with an undulated and scalloped edge and radiating ridges, corresponding to the scallops, and often extending out into spine-like projections on the lower valve. The upper valve is flatter, smooth at first, then with regular lamellæ or scales, scalloped at the edges, showing the stages of growth. Later in life, especially after the first winter, the growth becomes more irregular, and the form less symmetrical; and the irregularity increases with the age. Very old specimens, in crowded beds, usually become very much elongated, being often more than a foot long, and perhaps two inches wide. In the natural order of things this was probably the normal form attained by the adult individuals, for nearly all the oyster-shells composing the ancient Indian shell-heaps along our coast are of this much-elongated kind. Nowadays the oysters seldom have a chance to grow to such a good old age as to take this form, though such are occasionally met with in deep water. The young specimens on the rocks are generally mottled or irregularly radiated with brown. They were not often met with on the shores of Vineyard Sound, for oysters do not flourish well in that sandy region, though there are extensive beds in some parts of Buzzard's Bay, and a few near Holmes's Hole, in a sheltered pond. The oysters prefer quiet waters, somewhat brackish, with a bottom of soft mud

containing an abundance of minute living animal and vegetable organisms. In such places they grow very rapidly, and become fat and fine-flavored, if not interfered with by their numerous enemies. I shall have occasion to speak of the oyster again, when discussing the fauna of the estuaries, &c.

Another shell, related to the oyster and like it attached by one valve to some solid object, is common, adhering to the under sides and edges of rocks near low-water mark. This is the *Anomia glabra*, (Plate XXXII, figs. 241, 242,) and it is often called "silver-shell" or "gold-shell" on account of its golden or silvery color and shining luster; and sometimes "jingle-shell" from its metallic sound when rattling about on the beach with pebbles, &c. This shell, however, does not grow firmly to the rock like an oyster, but is attached by a sort of stem or peduncle, which goes out through an opening in the side of the lower valve; this is soft and fleshy at first, but late in life often becomes ossified, or rather calcified, and then forms a solid plug.

Of the lower classes of Mollusca, several Ascidians and Bryozoa occur under and among the rocks. Among the former the *Molgula Manhattensis* (Plate XXXIII, fig. 250) is the most common. This usually has a subglobular form, especially when its tubes are contracted, and is almost always completely covered over with foreign matters of all sorts, such as bits of eel-grass and sea-weeds, grains of sand, &c. When these are removed its color is dark or pale olive-green, and the surface is a little rough. This species is often attached to the underside of rocks, but is still more frequently attached to sea-weeds and eel-grass, and is sometimes so crowded as to form large clusters. Another species, having some resemblance to the last when contracted, is the *Cynthia partita*, (Plate XXXIII, fig. 246,) but besides the great difference in the tubes and apertures, this has a rougher and wrinkled surface and a rusty color. The specimens that grow on the under sides of stones are often much flattened, as in the figure, but it grows more abundantly attached to the piles of wharves and on shelly bottoms in shallow waters, off shore, and in such places assumes its more normal erect position, and a somewhat cylindrical form. Each aperture is marked with four alternating triangles of flake-white and purplish red. This and the preceding are eaten by the tautog. Most of the other ascidians are much more at home on the bottom, off shore, although some of them sometimes occur at low-water on rocks or in pools.

A delicate and elegantly branched bryozoan, the *Bugula turrita*, (Plate XXXIV, figs. 258, 259,) is often found attached to sea-weeds in the pools, and it is also frequently thrown up in large quantities by the waves, after storms. A smaller kind, with slender, ivory-white, and stellate branches, the *Crisia eburnea*, (Plate XXXIV, figs. 260, 261,) also occurs on the sea-weeds in pools. And with this is a coarser species, which forms calcareous crusts and tubercles, having the surface covered

with the prominent tips of the tubes; this is the *Cellepora ramulosa*, and like the *Crisia* it is a northern species, which inhabits also the shores of northern Europe. Still other species of bryozoa occur in these situations. One of the most abundant is *Alcyonidium hispidum*, which forms soft gelatinous incrustations around the stems of *Fucus*. On the under sides of the stones several additional kinds occur, the most common of which is the *Escharella variabilis*, (Plate XXXIII, fig. 256,) which forms broad calcareous crusts, often several inches across, and of some thickness, composed of small perforated cells. While living this species is dark-red or brick-red, but it turns green when dried, and then fades to yellow, and finally to white. It is far more abundant on shelly bottoms, off shore, in 3 to 10 fathoms of water, and in such places often covers every stone, pebble, and shell, over wide areas, and in some cases forms rounded coral-like masses two or three inches in diameter and more than an inch thick.

Crustacea in considerable numbers may also be found upon the rocky shores. Of crabs four or five species are common, concealed under the rocks and in crevices. The "green crab," *Carcinus granulatus*, occurs quite frequently well up toward high-water mark, hiding under the loose stones, and nimbly running away when disturbed. It may also be found, at times, in the larger tidal pools. Its bright green color, varied with spots and blotches of yellow, makes this species quite conspicuous. The common "rock-crab," *Cancer irroratus*, is generally common under the large rocks near low-water mark and often lies nearly buried in the sand and gravel beneath them. This species is usually larger than the preceding, often becoming three or four inches across the shell, and though less active it uses its large claws freely and with force. It can be easily distinguished by having nine blunt teeth along each side of the front edge of its shell or carapax, and by its reddish color sprinkled over with darker brownish dots. This crab also occurs in the pools, where the comical combats of the males may sometimes be witnessed. It is not confined to rocky shores, but is common also on sandy shores, as well as on rocky and gravelly bottoms off shore. It is widely diffused along our coast, extending both north and south, and is common even on the coast of Labrador. Like all the other species of crabs this is greedily devoured by many of the larger fishes, such as cod, haddock, tautog, black-bass, and especially by sharks and sting-rays. Two smaller kinds of crabs are also very abundant under the stones, especially where there is some mud. These are dark olive-brown and have the large claws broadly tipped with black. They are often called mud-crabs on account of their fondness for muddy places. One of these, the *Panopeus depressus*, (Plate I, fig. 3,) is decidedly flattened above, and is usually a little smaller than the second, the *Panopeus Sayi*, which is somewhat convex above. They are usually found together and have similar habits. A third small species of the same genus is occasionally met with under stones, but lives rather

higher up toward high-water mark, and is comparatively rare. This is the *Panopeus Harrisii*. It can be easily distinguished, for it lacks the black on the ends of the big claws and has a groove along the edge of the front of the carapax, between the eyes. This last species is also found in the salt marshes, and was originally discovered on the marshes of the Charles River, near Boston. All the species of *Panopeus* are southern forms, extending to Florida, or to the gulf-coast of the Southern States, but they are rare north of Cape Cod, and not found at all on the coast of Maine. They contribute largely to the food of the tautog and other fishes. The lobster, *Homarus Americanus*, is sometimes found lurking under large rocks at low-water, but less commonly here than farther north, as, for instance, about the Bay of Fundy. In this region it lives also on sandy and gravelly bottoms, off shore, but in rather shallow water. It is an article of food for many fishes, as well as for man. Active and interesting little "hermit-crabs," *Eupagurus longicarpus*, are generally abundant in the pools near low-water, and concealed in wet places beneath rocks. In the pools they may be seen actively running about, carrying upon their backs the dead shell of some small gastropod, most commonly *Anachis avara* or *Ilyanassa obsoleta*, though all the small spiral shells are used in this way. They are very pugnacious and nearly always ready for a fight when two happen to meet, but they are also great cowards, and very likely each, after the first onset, will instantly retreat into his shell, closing the aperture closely with the large claws. They use their long slender antennæ very efficiently as organs of feeling, and show great wariness in all their actions. The hinder part of the body is soft, with a thin skin, and one-sided in structure, so as to fit into the borrowed shells, while near the end there are appendages which are formed into hook-like organs by which they hold themselves securely in their houses, for these spiral shells serve them both for shields and dwellings. This species also occurs in vast numbers among the eel-grass, both in the estuaries and in the sounds and bays, and is also frequent on nearly all other kinds of bottoms in the sounds. It is a favorite article of food for many of the fishes, for they swallow it shell and all. A much larger species, belonging to the same genus, but having much shorter and thicker claws, (*Eupagurus pollicaris*,) is also found occasionally under the rocks at low-water, but it is much more common on rocky and shelly bottoms in the sounds and bays. Its habits are otherwise similar to the small one, but it occupies much larger shells, such as those of *Lunatia heros*, *Fulgur carica*, &c. This large species is devoured by the sharks and sting-rays.

The Amphipods are also well represented on the rocky shores by a considerable number of species, some of which usually occur in vast numbers. These small crustacea are of great importance in connection with our fisheries, for we have found that they, together with the shrimps, constitute a very large part of the food of most of our more valu-

able edible fishes, both of the fresh and salt waters. The Amphipods, though mostly of small size, occur in such immense numbers in their favorite localities that they can nearly always be easily obtained by the fishes that eat them, and no doubt they furnish excellent and nutritious food, for even the smallest of them are by no means despised or overlooked even by large and powerful fishes, that could easily capture larger game. Even the voracious blue-fish will feed upon these small crustacea, where they can be easily obtained, even when menhaden and other fishes are plenty in the same localities. They are also the favorite food of trout, lake white-fish, shad, flounders, scup, &c., as will be seen from the lists of the animals found in the stomachs of fishes. One species, which occurs in countless numbers beneath the masses of decaying sea-weeds, thrown up at high-water mark on all the shores by the waves, is the *Orchestia agilis* SMITH, (Plate IV, fig. 14,) which has received this name in allusion to the extreme agility which it displays in leaping, when disturbed. The common name given to it is "beach-flea," which refers to the same habit. Its color is dark olive-green or brown, and much resembles that of the decaying weeds among which it lives, and upon which it probably feeds. It also constructs burrows in the sand beneath the vegetable debris. It leaps by means of the appendages at the posterior end of the body.

A much larger species, and one of the largest of all the amphipods, is the *Gammarus ornatus*, (Plate IV, fig. 15,) which occurs in great numbers beneath the stones and among the rock-weed near low-water mark. The males are much larger than the females, and sometimes become nearly an inch and a half long. They cannot leap like their cousins that live at high-water mark, but skip actively about on their sides among the stones and gravel, until they reach some shelter, or enter the water, when they swim rapidly in a gyrating manner back downward, or sideways. But although they can swim they are seldom met with away from the shore or much below low-water mark: The zone of *Fucus* is their true home. This species is abundant on all our shores, wherever rocks and *Fucus* occur, from Great Egg Harbor, New Jersey, to Labrador. Its color is generally olive-brown or reddish-brown, much like that of the *Fucus* among which it lives. The only good English name that I have ever heard for these creatures is that of "scuds" given by a small boy, in reference to their rapid and peculiar motions.

Another smaller species, *Gammarus annulatus* SMITH, frequently occurs under stones in similar places, but usually a little higher up. This is a pale species, having darker bands, with red spots on the sides of the abdomen. Still higher up, *G. marinus* often occurs.

With the *Gammarus ornatus* another, much smaller, light slate-colored amphipod is generally to be found. This is the *Melita nitida* SMITH. Its habits appear to be similar to those of the *Gammari*. Another small